

**WRITTEN STATEMENT  
OF THE  
MANUFACTURERS OF EMISSION CONTROLS ASSOCIATION  
ON THE  
AIR RESOURCES BOARD'S DRAFT EMISSION REDUCTION PLAN FOR  
PORTS AND INTERNATIONAL GOODS MOVEMENT IN CALIFORNIA**

*February 6, 2006*

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The Manufacturers of Emission Controls Association (MECA) is pleased to provide testimony in response to California Air Resources Board's request for public comment on the Draft Emission Reduction Plan for Ports and International Goods Movement in California. MECA firmly believes that the emission control technologies that will be needed to help meet the emission reduction goals stated in the draft Plan will be available. The particulate matter (PM) and nitrogen oxides (NOx) control technologies cited in the ARB's Draft Emission Reduction Plan are being used today on on-road and off-road applications in California and elsewhere. ARB's proposed emission reduction strategies outlined in the draft Plan will provide important and rapid PM and NOx emission reduction benefits and will provide an opportunity to demonstrate the effectiveness of a retrofit/rebuild/replacement strategy for diesel engines used in goods movement-related activities.

MECA is a non-profit association of the world's leading manufacturers of emission control technology for motor vehicles. Our members have decades of experience and a proven track record in developing and manufacturing emission control technology for a wide variety of on-road and off-road vehicles and equipment. A number of our members have extensive experience in the development, manufacture, and application of PM and NOx control retrofit technologies.

Our members have invested and continue to invest significant resources in developing and verifying diesel retrofit technologies for use on the whole range of in-use diesel engines currently operating in California, including on-road, off-road, and stationary sources. To date, the majority of the retrofit technologies verified using ARB's verification procedures have targeted on-road diesel engines. Many of these retrofit technologies verified for on-road engines can also be successfully applied to appropriate off-road diesel engines, such as those used in construction equipment, airport ground service equipment, cargo handling equipment, oceangoing vessel, locomotive, and commercial harbor craft. MECA believes that there is an opportunity to greatly expand the range of verified off-road technologies available for off-road applications through the extension of existing on-road verifications. Sound engineering principles based on the knowledge of engine size, duty cycle, exhaust temperature history, and engine-out emission characteristics can all be used to define appropriate off-road applications for existing verified on-road retrofit technologies. This type of engineering analysis complemented in some cases with limited engine test data can streamline and accelerate the verification extension process without the need for expensive and time consuming testing associated with the full-scale, verification extension process that

would help deliver more verified options to the off-road sector, and expand the verified retrofit technology options available for diesel vehicles operators used in goods movement in California.

MECA has recently provided ARB staff with a list of recommendations for improving the efficiency and effectiveness of their diesel retrofit verification protocols. MECA requested that ARB respond to these recommendations in a timely manner so that a more streamlined verification process can be put in place. MECA strongly believes that ARB's retrofit verification program must be adequately resourced and designed to ensure the efficient transfer of proven, verified technologies to the marketplace that will deliver needed emission reductions from the full application range of diesel engines used in California goods movement sectors.

### **Technologies to Reduce Diesel PM and NO<sub>x</sub> Emissions**

The ARB Draft Emission Reduction Plan provides a summary of emission control technology options available to reduce PM and NO<sub>x</sub> emissions from existing on-road and off-road vehicles utilized in goods movement in California. MECA offers some additional comments regarding the technological feasibility of these technologies to meet diesel emission reduction goals.

A number of advanced emission control technologies exist today to significantly reduce PM and NO<sub>x</sub> emissions from new and existing diesel engines. These include diesel particulate filters (DPFs), diesel oxidation catalysts (DOCs), selective catalytic reduction (SCR), NO<sub>x</sub> adsorbers, lean NO<sub>x</sub> catalysts, and exhaust gas recirculation (EGR).

*Diesel Particulate Filters* – Diesel particulate filters (DPFs) are commercially available today. Over 200,000 on-road heavy-duty vehicles worldwide have been retrofit with passively or actively regenerated DPFs. In addition, over one million new passenger cars have been equipped with DPFs in Europe since mid-2000, and starting in 2007 every new heavy-duty on-road engine sold in the U.S. and Canada will be equipped with a high-efficiency DPF. The operating and durability performance of DPFs has been very impressive. For example, a growing number of on-road DPF-equipped heavy-duty vehicles have been successfully operating for several 100,000 miles or more. In addition to the successful retrofit programs, other examples of successful programs include urban transit agencies in many large U.S. and European cities, the New York City and city of Los Angeles Departments of Sanitation fleets, which have successfully retrofitted refuse trucks with filters, and thousands of school buses across the U.S. DPFs have also been successfully retrofitted in a number of off-road applications including applications on construction equipment, mining equipment, and cargo handling equipment used at the ports of Oakland, Long Beach, and Cleveland.

High-efficiency DPF technology can reduce PM emissions by up to 90 percent or more, ultra-fine carbon particles by up to 99+ percent and, depending on the system design, toxic HC emissions by up to 80 percent or more. In general, verified DPF

technologies require the use of ultra-low sulfur diesel fuel to achieve Level 3 PM reductions. Ultra-low sulfur diesel fuel will be required to be used by all on-road, off-road, and stationary diesel engines in California starting in mid-2006.

New “partial” filter technologies are also emerging for diesel retrofit applications. These “partial” filters make use of wire mesh supports or tortuous metal substrates that employ sintered metal sheets. Two “partial” filter designs have been verified by ARB as Level 2 PM reduction technologies and one “partial” filter design that employs a fuel-borne catalyst for assisting in soot regeneration has been verified by the U.S. EPA. These “partial” filter designs are less susceptible to plugging and can offer PM reduction efficiencies in the 60-75 percent range.

Development work is underway to further enhance the performance of filter system designs. For example, work continues on developing and implementing additional filter regeneration strategies that will expand the applications for retrofitting DPFs. Also, development work on filter materials and designs to further enhance filter system durability and to further reduce backpressure are under development. Manufacturers are also developing DPF options that minimize NO<sub>2</sub> emissions in systems that make use of NO<sub>2</sub> for filter regeneration. New, improved DPF systems continue to enter the diesel engine OE and retrofit market.

For off-road engines, DPFs have been successfully installed and used on mining, construction, and materials handling equipment where vehicle integration has been challenging. These off-road applications include the use of both passive and active filter regeneration strategies. Active off-road DPF options include diesel fuel injection strategies, engine throttling strategies, the use of electrical heating elements, and fuel burners. Over 20,000 active and passive systems have been installed on off-road applications as either original equipment or as a retrofit worldwide. Some off-road filter systems have been operated for over 15,000 hours or over 5 years and are still in use.

Particulate filters, many employing active regeneration strategies such as fuel burners or electrical resistance heaters, have also been used on over 100 locomotives in Europe since the mid-1990s providing in excess of an 85 percent reduction in PM emissions. Some of these systems have been operating effectively for over 650,000 kilometers. The European locomotive applications include DPFs installed on Caterpillar 3512 and 3516 engines powered at 1100 and 1500 kW, respectively. Active DPF retrofit systems are also being evaluated in a railroad industry sponsored test program at Southwest Research Institute (San Antonio, TX) using a two-stroke, V-16 locomotive engine rated at 1490 kW @ 900 rpm. Active DPF systems have also been used in Europe on a limited number of commercial marine diesel engines including sight-seeing ships used on lakes in Switzerland.

*Diesel Oxidation Catalysts (DOCs)* – DOC technology is available today and represents a cost-effective, interim PM control strategy. Over 250,000 off-road vehicles and equipment, including mining vehicles, skid steer loaders, forklift trucks, construction vehicles, cargo handling equipment, marine diesel engines, and stationary engines, as

well as over 50,000,000 diesel passenger cars and over 1.5 million trucks and buses worldwide have been equipped with DOCs. Control efficiencies of 20-50 percent for PM, up to 90 percent reductions for carbon monoxide (CO) and hydrocarbon (HC), including large reductions in toxic hydrocarbon species have been achieved and reported in tests of DOCs on a large variety of on-road and off-road diesel engines. With respect to particulate emissions, the wide range of PM reductions observed with DOCs reflects the fact that DOCs oxidize soluble hydrocarbons associated with PM (the so-called soluble organic fraction [SOF] of PM). The SOF content of PM is related in part to the oil consumption characteristics of diesel engines.

*Selective Catalytic Reduction (SCR) Technology* – SCR technology is a proven NO<sub>x</sub> control strategy. SCR has been used to control NO<sub>x</sub> emissions from stationary sources for over 15 years. More recently, it has been applied to select mobile sources including trucks, marine vessels, and locomotives. In 2005, SCR using a urea-based reductant was introduced on a large number of on-road diesel heavy-duty engines to help meet the Euro 4 heavy-duty NO<sub>x</sub> emission standards. SCR is also being given serious consideration by engine manufacturers for complying with future on-road heavy-duty diesel engine emission standards in both the U.S. and Japan (in the 2009-2010 timeframe). Applying SCR to diesel-powered engines provides simultaneous reductions of NO<sub>x</sub>, PM, and HC emissions. Since the mid-1990s, SCR technology using a urea-based reductant has been installed on a variety of marine applications in Europe including ferries, cargo vessels, and tugboats with over 100 systems installed on engines ranging from approximately 450 to 10,400 kW. These marine SCR applications include the design and integration of systems on a vessel's main propulsion engines and auxiliary engines. Most recently an SCR system has been successfully installed on one of New York City's Staten Island ferries. A smaller number of SCR systems have also been installed on diesel locomotives, largely in Europe.

SCR has also been combined with DPF technology to provide simultaneous large reductions in NO<sub>x</sub> and PM emissions as well as reductions in CO and hydrocarbon emissions. In California, a 300-ton gantry crane powered by a turbocharged, after-cooled diesel engine rated at 850 kW was equipped with such a combined emission system in 2001. The expected emission reductions were an 85 percent reduction of particulate matter and a 90 percent reduction in NO<sub>x</sub>. A few combined SCR/DPF systems have also been installed on stationary diesel engines used for power production including six Caterpillar 3516B engines operating in southern California. Volvo AB, in the summer of 2004, launched 27 diesel transit buses in Sweden that are operating with a combined SCR/DPF system to reduce PM and NO<sub>x</sub> emissions below the European Euro 5 heavy-duty emission limits that do not come into force until 2008. A number of small test fleets of heavy-duty over-the-road diesel vehicles are also operating within the U.S. to demonstrate the capabilities of combined PM and NO<sub>x</sub> control using SCR and DPFs. DOE's (U.S. Department of Energy) APBF-DEC program included the evaluation of two different combined SCR/DPF systems on a 12 liter heavy-duty diesel engine. Results on this program were reported at the 11<sup>th</sup> Annual DEER (Diesel Engine Emission Research) Conference during the week of August 21, 2005. These results included the operation of these two different SCR/DPF systems for 6,000 hours of durability with emission

performance near the EPA 2010 heavy-duty on-road emission limits. A final report on this APBF-DEC project is expected in 2006 detailing the performance of these SCR/DPF systems through 6,000 hours of engine aging.

*NOx Adsorber Technology* – MECA believes that NOx absorber technology will also be an available NOx control strategy to help reduce NOx emissions from new diesel engines. NOx adsorber catalysts are currently being used commercially in light-duty gasoline direct injection (GDI) engines sold in Europe and Japan. This technology continues to undergo extensive research and development in preparation for the U.S. 2010 on-road heavy-duty and Tier 4 off-road diesel engine requirements. The progress in developing and optimizing this technology has been extremely impressive. Indeed, the Clean Diesel Independent Review Panel, charged by EPA to assess the technological progress in meeting the 2007/2010 standards, concluded in latter part of 2002, that NOx adsorber technology development was on track to help meet the on-road heavy-duty engine standards and no technological roadblocks were identified. Information presented at DOE's 11<sup>th</sup> Annual DEER Conference during the week of August 21, 2005 summarized information on a heavy-duty NOx adsorber/DPF system test program that was run as part of DOE's APBF-DEC program. In this test program a 90 percent NOx efficiency level was maintained through 2000 hours of durability including numerous high temperature desulfation events.

The current focus of NOx adsorber technology development and optimization is on: 1) expanding the operating temperature window in which the technology will perform, 2) improving the thermal durability of the technology, 3) improving the desulfurization methods and performance, and 4) improving system packaging and integration. The progress being made in these areas continues to be impressive. In light-duty applications, several automobile manufacturers are conducting in-vehicle tests with NOx adsorber/DPF systems (see for example, SAE Paper No. 2004-01-1791 for EPA's emission tests of prototype vehicles equipped with NOx adsorber/DPF systems) and Toyota has introduced a diesel-powered passenger car in Europe and a diesel-powered light-duty truck in Japan with a combined NOx adsorber/DPF system in late 2003. Recently Mercedes-Benz announced its plans to introduce a diesel passenger car into the U.S. market in late 2006 equipped with a NOx adsorber/DPF system.

*Low-Pressure EGR* – This technology is being successfully demonstrated in retrofit applications on trucks, buses, and other applications. Over 2,000 systems are running worldwide. Low-pressure EGR has demonstrated a NOx control capability in the range of 30 to 60 percent. ARB has verified a low-pressure EGR/DPF system with 40 percent NOx reduction for a range of on-road diesel engines. With an active DPF and <15 ppm sulfur diesel, NOx control levels as high as 80 percent may be achievable. Current experience with low-pressure EGR is in the 140-330 kW range, with a new larger EGR valve now being offered to cover diesel engine applications up to 750 kW.

*Lean NOx Catalyst (LNC) Technology* – This technology has been verified by ARB (25% NOx control) for specific on-road diesel retrofit applications. This technology, which is being used in combination with both DPFs or DOCs, is being also

demonstrated and commercialized for a variety of non-road retrofit applications, including heavy-duty earthmoving equipment, locomotives, agricultural pumps, and portable engines.

*Crankcase Emission Controls* – Crankcase emissions from diesel engines can be significant and can be controlled by the use of a multi-stage filter designed to collect, coalesce, and return the emitted lube oil to the engine's sump. Filtered gases are returned to the intake system, balancing the differential pressures involved. Typical systems consist of a filter housing, a pressure regulator, a pressure relief valve and an oil check valve. These systems have the capability to virtually eliminate crankcase emissions. This technology is currently being used in Europe on new engines as well as the United States on a retrofit basis. Closed crankcases with filtration systems will be required on new heavy-duty on-road and non-road diesel engines as part of EPA's regulatory programs covering these applications.

## **Conclusion**

In closing, we commend the Air Resources Board for its continuing efforts to provide the people of California with healthy air quality and for demonstrating true leadership in developing innovative strategies to significantly reduce PM and NOx emissions from diesel vehicles and equipment used in port and international goods movement in California. Our industry is prepared to do its part to help meet the emission reduction goals outlined in the Draft Emission Reduction Plan.

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